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Parametric Sonar as Applied to High Resolution Boundary Scattering

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Preface

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The use of the parametric acoustic source with its narrow beam and lack of side lobes permits measurement of sea surface and bottom forward and back scatter to very low grazing angles. Measurements using conventional sources are often contaminated by side lobe or other unwanted returns that result when unavoidably large boundary areas are illuminated. This paper (presented at the 104th Meeting of the Acoustical Society of America) describes the design and performance of one parametric source that has been employed for such measurements.

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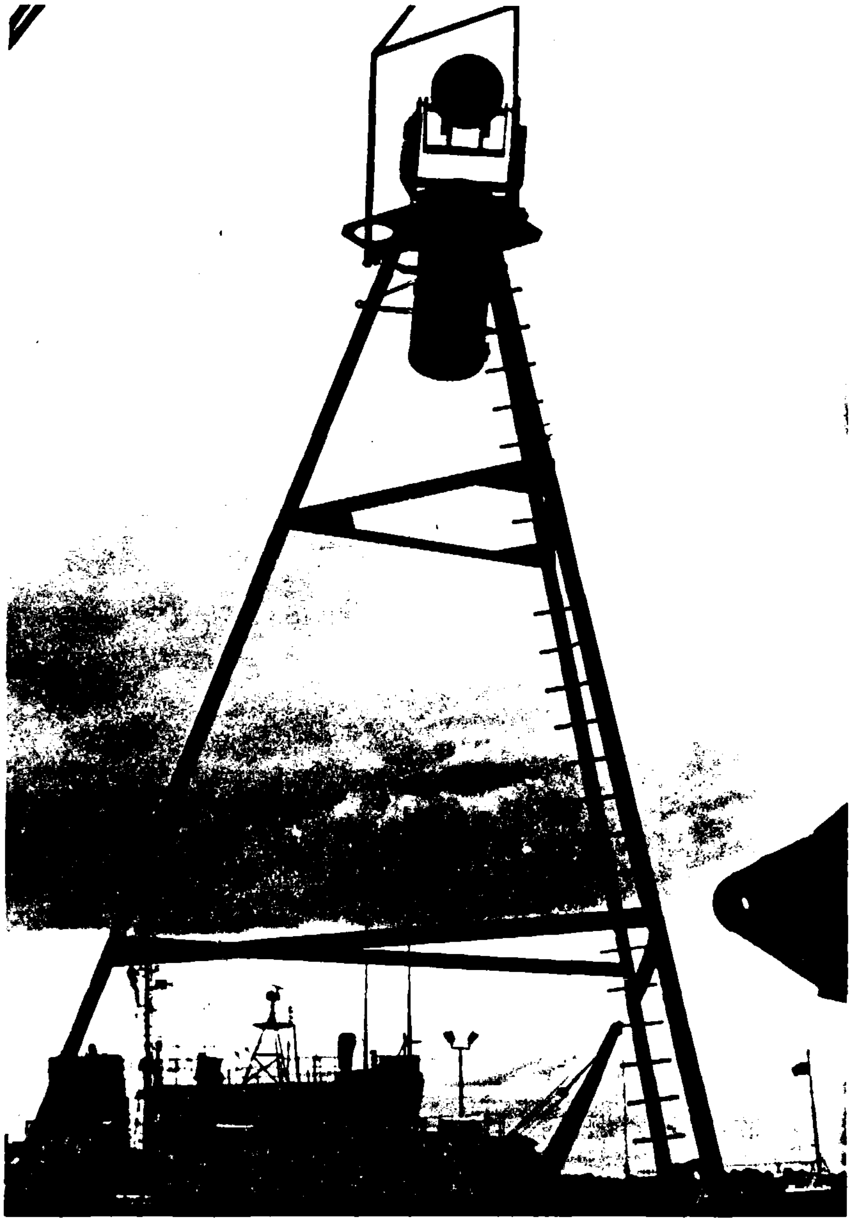
Parametric Sonar as Applied to High Resolution Boundary Scattering

The use of the parametric acoustic source[1,2,3] for sea boundary measurements affords greater reliability and assurance that the desired arrivals will be uncontaminated by arrivals propagating by undesired paths. This is especially true when measurements are extended to low grazing angles. The measurements of interest include surface and bottom, forward and backscatter, and also the deep scattering layer.

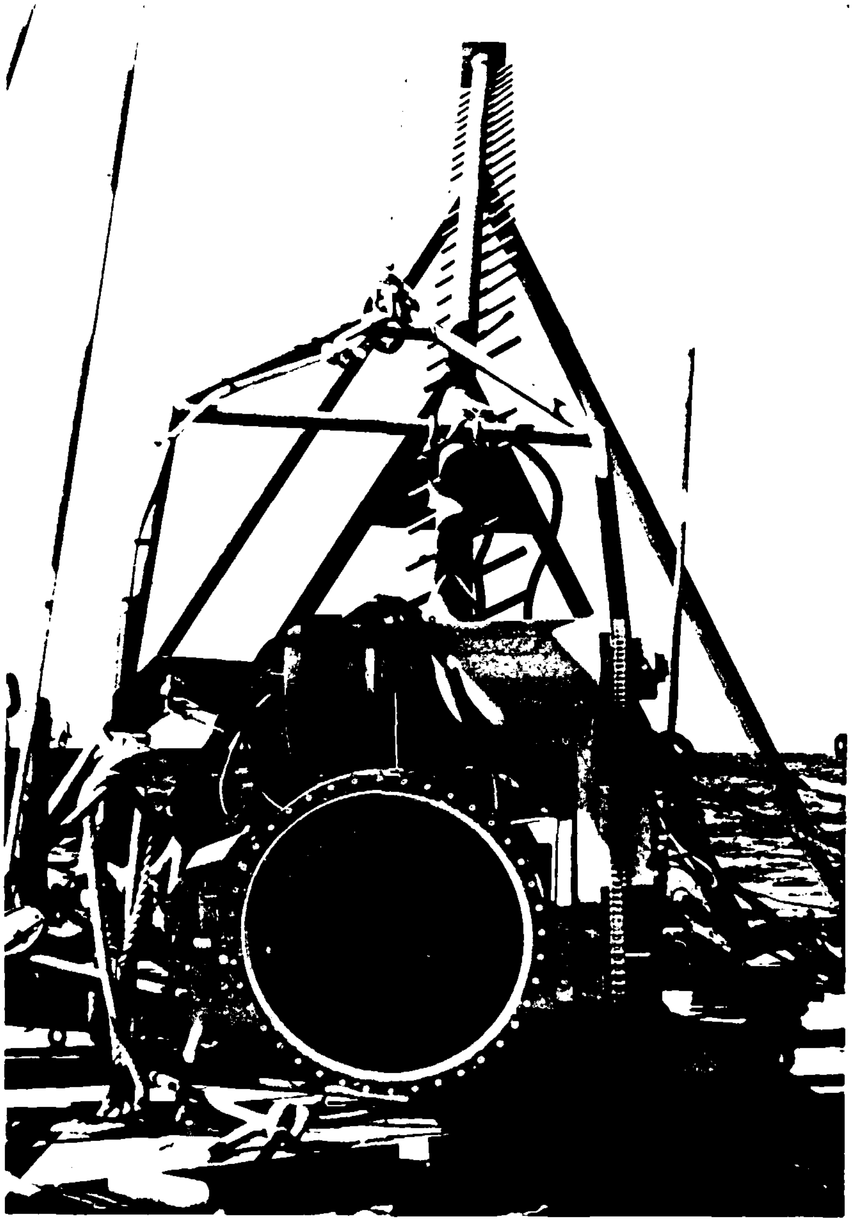
Today, I will describe the parametric sources used in some of these programs at the Naval Underwater Systems Center. While this paper emphasizes the source characteristics, I will also show examples of the data obtained from two of the measurement programs.

— First slide, please. —



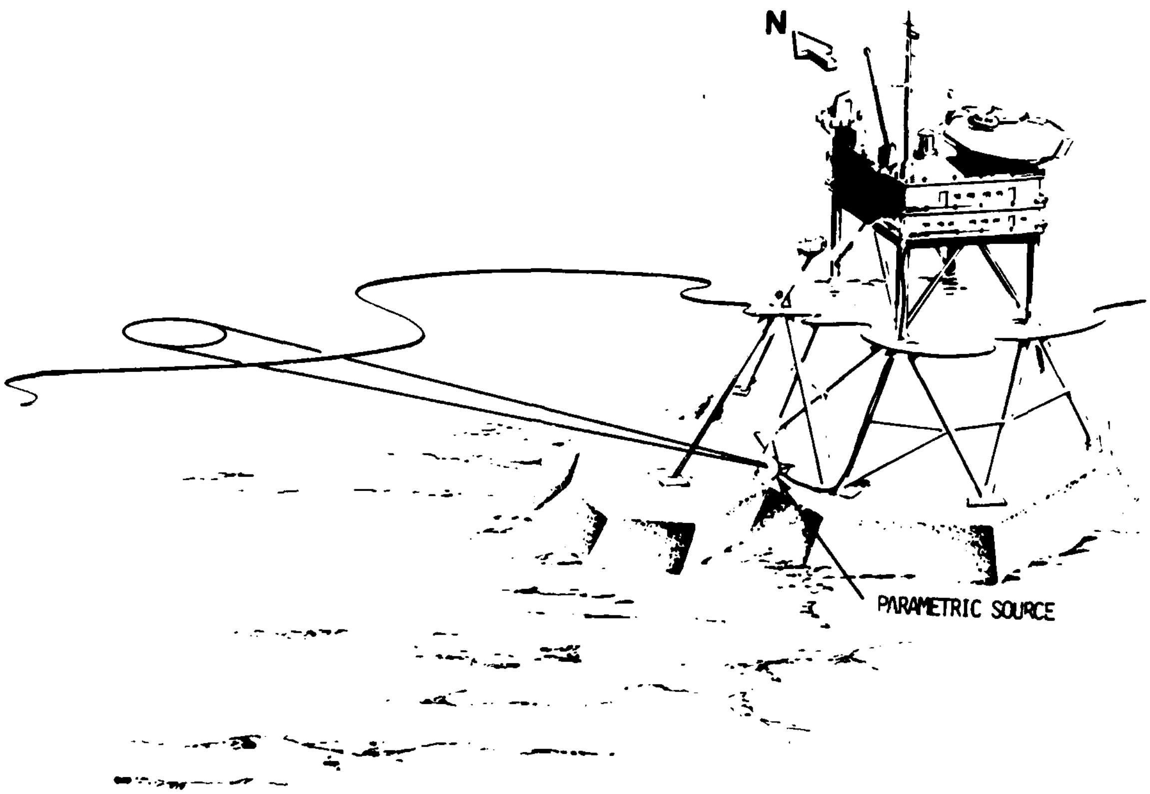
Slide 1

This shows the parametric transducer called SPA (special purpose array) mounted atop a 9-m tower. This array was placed on the bottom in 35 m of water off Block Island, Rhode Island, in April of this year. Measurements of surface and bottom, forward and backscatter covered grazing angles from 5 to 90° and difference frequencies from 5 to 20 kHz. The resulting data are presently being analyzed.



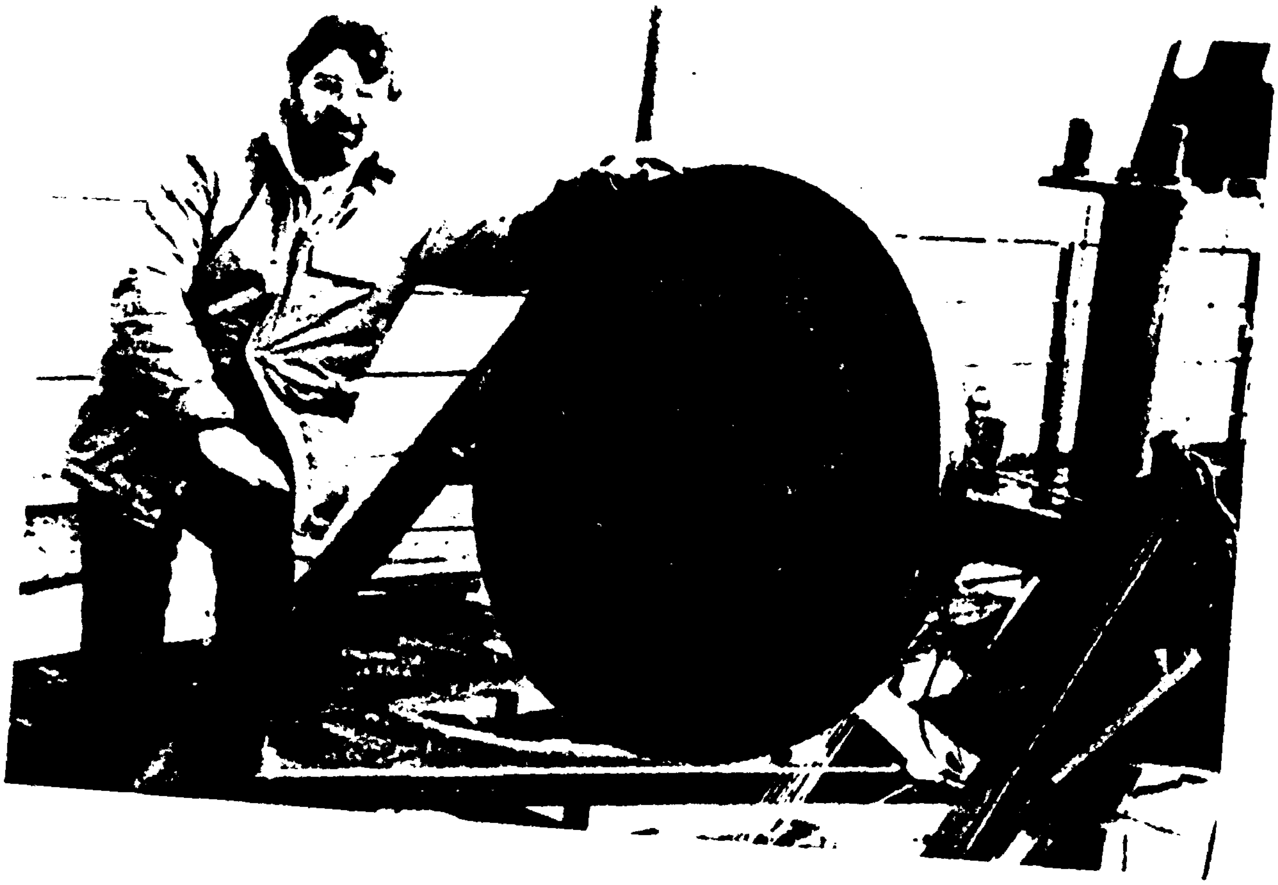
Slide 2

A close-up of the SPA transducer is shown here. The mechanical training mechanism permits remote training over 360° of azimuth and from straight up to 50° below horizontal. The system was connected by electrical cable to a ship moored at four points. A vertical hydrophone array suspended from the ship 300 m from the tower was used for the forward scatter measurements.



Slide 3

This illustrates the installation of a NUSC parametric source below the NORDSEE, a tower in the North Sea owned by Germany and operated by a German corporation. It is located 70 miles north of Germany's north coast in 30 m of water and serves as a station for a wide range of research programs. A hydrophone aligned azimuthally in the beam and positioned at a range of 300 m permitted forward scatter measurements. Backscatter data were taken using the parametric projector as the hydrophone. These measurements wer: made during February 1981.



Slide 4

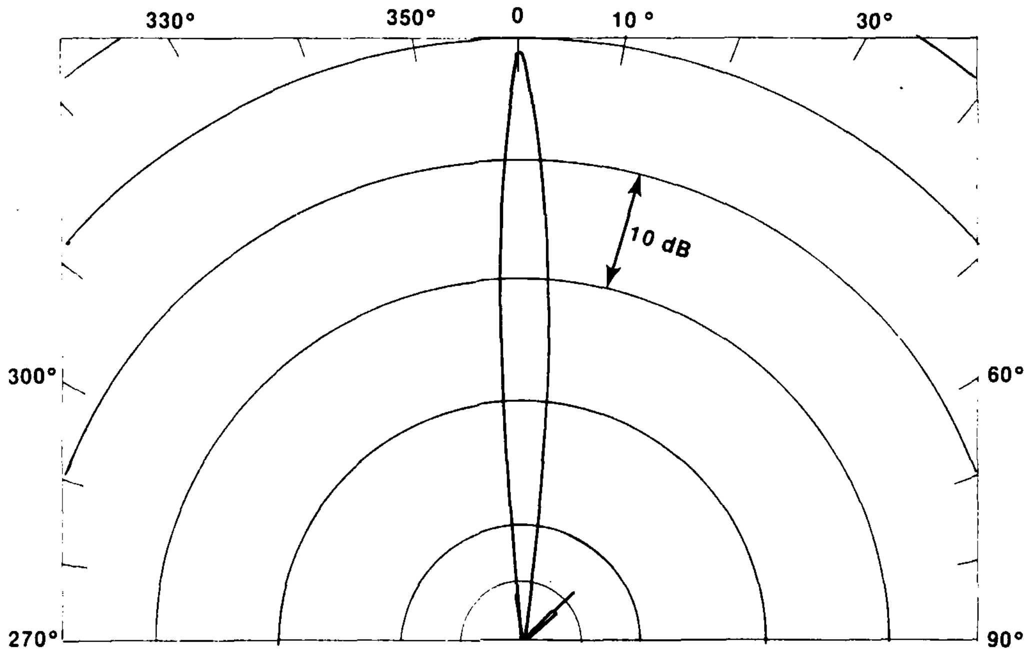
This is the 65 transducer shown mounted on the frame, which permitted remote mechanical training in elevation only.

PARAMETRIC SOURCE CHARACTERISTICS

NAME	65	SPA
DIAMETER (m)	0.9	0.5
CONSTRUCTION	2400 – ½λ PRESSURE RELEASE	456 TONPILTZ 1.9 × 1.6 m
PRIMARY FREQUENCY (kHz)	65	60
INPUT POWER (2FREQ AVG)(kW)	10	10
DIFFERENCE FREQ RANGE (kHz)	2 – 20	3 – 20
SOURCE LEVELS (dB//μPa·m)	190 – 224	190 – 215
BEAM WIDTHS (degrees)	4 – 2	4 – 3.5

Slide 5

The characteristics of the 65 and SPA parametric sources are outlined here. The SPA, with an aperture of 0.5 m, is considerably smaller than the 65 and uses mass-loaded elements as opposed to the 65's one-half wave pressure release construction. Primary mean frequencies are similar as are their power inputs of 10 kW. The range of difference frequencies is determined by the transducer bandwidth on the high end and minimum useful source level at the low frequency end. Beamwidth variation over this band is small, which is an advantageous feature for most measurements.

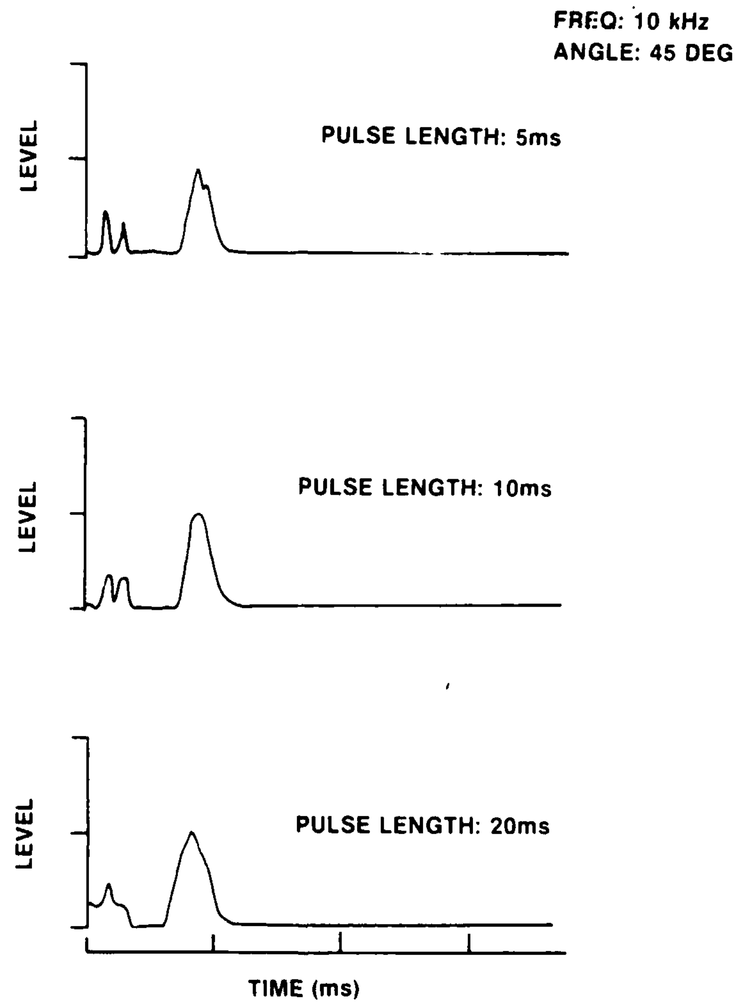


PARAMETRIC BEAM PATTERN
65 Transducer f = 12kHz

Slide 6

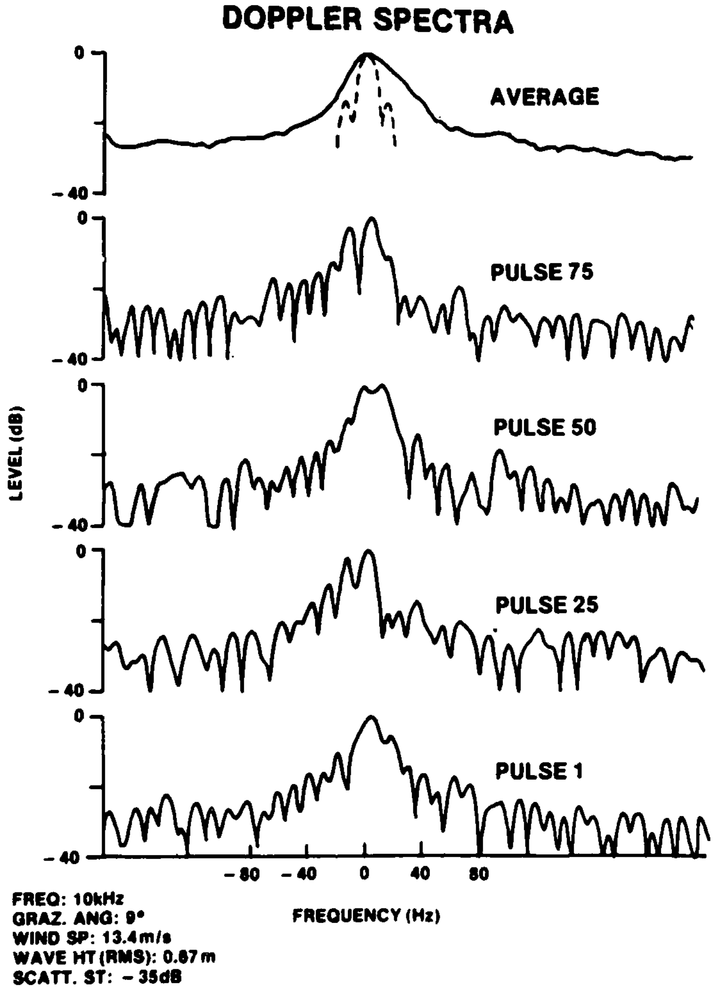
The beam pattern of the 65 source at a difference frequency of 12 kHz is shown here. At this point, I must call attention to a feature that has caused us a problem in the measurement of some grazing angles. Although the side lobe, which appears at about 45°, is 43 dB below the main lobe, it managed to contaminate some of the measurements from the NORDSEE tower. This side lobe results from direct radiation[4] of 12 kHz generated in the electronics. An examination of the projector pattern at 12 kHz discloses a large asymetrical side lobe at the same bearing as the spurious side lobe. Improved high pass filtering should eliminate the problem.

SHALLOW WATER REVERBERATION RETURNS



Slide 7

Here are shown 3 backscatter "A" scans from the NORDSEE tower data at 10 kHz and 45° grazing angle for pulse lengths of 5, 10, and 20 ms. The first arrival is the surface and surface-bottom at normal incidence resulting from the undesired side lobe. The second arrival is the desired 45° backscatter from the surface at a slant range of about 140 m, while the third arrival is via the 45° forward-surface reflection and the bottom. Notice that when the pulse length reaches 20 ms the desired and unwanted returns merge. This interference is troublesome when longer pulse lengths are required to increase frequency spectra resolution.



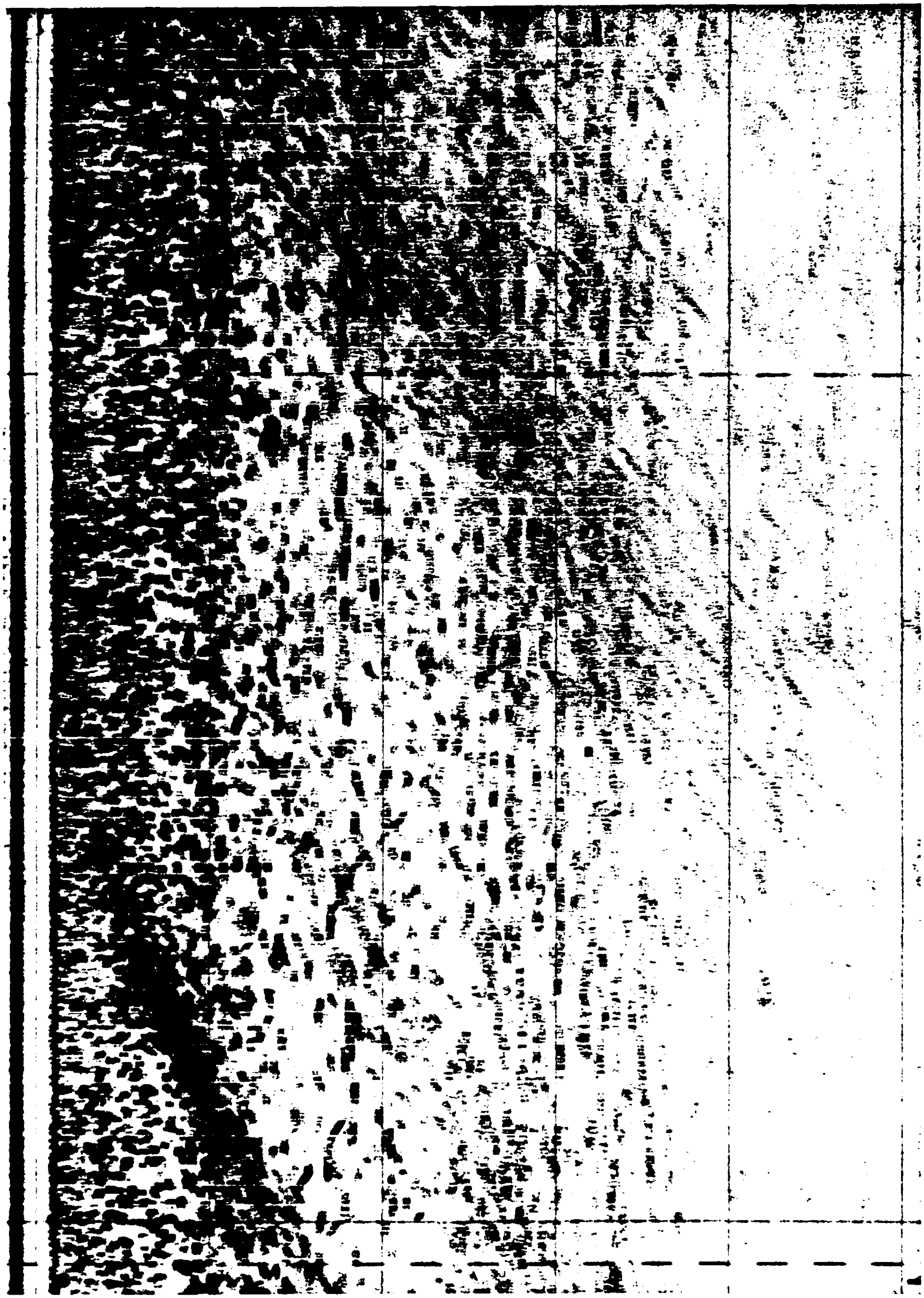
Slide 8

This is illustrative of one type of data obtained from the North Sea experiment. The top trace shows the Doppler spectrum of an ensemble average of 100 pulses each 100 ms long and backscattered at a grazing angle of 9°. Shown below are 4 individual pulse spectra. The beam was directed at an approaching sea so that the spectrum is skewed upward in frequency. The dashed spectrum represents that of the transmitted pulse. This type of data would not be possible without the very low side lobe level of the parametric source.


1630
1600

Slide 9

While scattering layers are not boundaries in the same sense as the surface and bottom, the layers can exhibit quite high reflective or scattering strengths. Here the 65 parametric source transmitting a 5 ms-pulse was directed vertically downward in a fathometer mode with a difference frequency of 20 kHz. The recording was obtained during September of this year in the Tongue-of-the-Ocean in the Bahamas and starts at 1600 hours at the dashed line on the left and continues to 1630, or about 2½ hours before sunset. The ship was drifting less than 0.5 knot during this period. The depth between horizontal lines is 75 m. Discrete returns in the first 50 m are probably individual fish illuminated by the 2° beam. Below are schools, some at constant depth and some rising as evening approaches.



Slide 10

Here again in the Tongue, but 2½ hours later from 1830 to 1900, the deep layer is migrating upward and the depth spread of discrete targets near the surface has increased. Scattering strengths as high as -60 dB were measured. To compare a conventional source with the parametric the 65 projector was fed with 20 kHz directly. The resulting beamwidth of 5° with side lobes produced a smearing that prevented counting of the individual returns in many cases.

Conclusion

In conclusion, the parametric source has demonstrated a capability of obtaining high quality oceanographic acoustic data. Its primary attribute of a narrow beam from a small manageable size projector can virtually eliminate unwanted returns in the case of low grazing angle measurements and provide high resolution data from biological targets. To obtain these benefits, however, care must be taken to avoid problems peculiar to the parametric source, such as direct radiation of the difference frequency or excessive primary side lobe levels, that can produce unwanted lobes in the difference frequency.

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4. W. L. Konrad, *Design Performance of Parametric Sonar Systems*, NUSC Technical Report 5227, 24 September 1975.

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